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EXECUTIVE SUMMARY

The National Center for Appropriate Technology (NCAT) contracted with the Montana Department of Environmental Quality (DEQ) in the winter of 1999 to organize three workshops to educate snowmobile operators, rental agencies and manufacturers about the environmental benefits of certain practices and products. The first workshop took place in West Yellowstone, MT on March 15th, 2000. The second two workshops took place in Minneapolis, MN on November 11th and 12th , 2000. As a supplement to these workshops, NCAT created a portable static display that features information on emissions research, alternative fuels and lubricants, new snowmobile engine technologies, and the engineering student competition known as the Clean Snowmobile Challenge 2000. This portable display was set up for three days at the Minneapolis workshops. This report documents these educational outreach activities and provides some recommendations on how NCAT and DEQ might continue in this educational effort.

SECTION I

WEST YELLOWSTONE CLEAN SNOWMOBILE TECHNOLOGY WORKSHOP
The National Center for Appropriate Technology (NCAT) offered a free Clean Snowmobile Technology Workshop at Three Bear Lodge in West Yellowstone, Montana, on March 15, 2000. The workshop was sponsored by the Montana Department of Environmental Quality (DEQ), the United States Environmental Protection Agency (EPA) Air Quality Transportation Outreach Program, and the U.S. Department of Energy (DOE) Regional Bioenergy Program.

This workshop addressed issues raised in regard to the thousands of snowmobiles that enter Yellowstone National Park each year. These issues include airborne emissions. Most snowmobiles are powered by two-stroke engines that emit 20 to 30 percent of their fuel unburned. The U.S. Environmental Protection Agency (EPA) is scheduled to draft the first emission standards for these and other two-stroke powered vehicles by September, 2001. These new rules are likely to force manufacturers to redesign or replace the two-stroke engine in future snowmobiles.

Speakers at this event included Howard Haines, bioenergy engineering specialist with DEQ; Jeff White, Certification, Audit and Compliance Department of Emission Research Manager at the Southwest Research Institute (SwRI); Glen Loomis, snowmobile enthusiast and owner of Traveler's Snowmobile Rental in West Yellowstone, Montana; and Lori Fussell, one of the primary organizers of the Clean Snowmobile Challenge 2000. More details and facts of the presentations can be found in the attached Microsoft Power Point slide presentations in section IV.

Workshop Introduction
Howard Haines began the event by asking the audience what they believed to be the biggest concerns relative to snowmobile emissions. Responses included carbon monoxide (CO), particulate matter (PM), hydrocarbons (HC), and noise. Haines agreed that these are in fact the major causes of complaints from snowmobile operators. The complaints include illness, fatigue, headaches, poor visibility, odor, and noise.

Haines gave an overview of previous workshops and research documents that formed the basis of the research he was discussing. These studies relate to snowmobiles, emissions, new technologies, and the benefits the new technologies may have for riders and the environment. Jeff White performed these studies in the lab, Jerry Bishop studied emissions in the field, George Ingersoll studied what was left behind in the snowpack, and Rick Peterson and Bonnie Tyler measured particulate size. Norm Kato studied the effects on Park Service personnel. Lori Fussel developed a mathematical model to estimate levels of CO that occur in the breathing area of individuals following snowmobiles. Noise has not been studied as thoroughly, although OSHA did a study and the manufacturers have been approached and a practical field test method is being developed.

SwRI Emissions Research

The next section of the workshop was a presentation by Jeff White on emissions from snowmobile engines and technology available to reduce those emissions. Prior to research conducted at the Southwest Research Institute, very little information was available on snowmobile emissions. The Southwest Research Institute presented information on the state of the current technology, and on the potential benefits of certain types of fuels and lubricants.

Audience Questions and Answers with Jeff White:

1. *How long were engines run at each mode?*

   JW: 15-20 minutes

2. *What is your overall recommendation for best combination to use in Yellowstone area?*

   JW: Ethanol blend was a clear winner. The best choice of lubricant is less clear but lubricants do have a real impact on particulate matter.

   HH: We haven't tested all 15-20 biodegradable lubes that are available, but there are several available low-emission lubes to reduce emissions and improve performance.

3. *Why haven't manufacturers done these studies in the past?*

   JW: Until recently, emissions were not seen as of primary importance.

   HH: Three snowmobile manufacturers now produce biodegradable lube oils. Only one was available when we started testing.

4. *Did you have to tinker with engines to use ethanol blend?*

   JW: No.

5. *Have you looked at different levels of oxygenation?*

   JW: No. We used a 10% ethanol blend, the legal limit.

6. *Were carbureted engines cleaner than fuel-injected ones?*

   JW: We haven't looked at fuel-injected engines.

7. *What is NOx?*

   JW: NOx or oxides of nitrogen are nitrates, a standard measured pollutant.

8. *What's your objective? To decrease all pollutants?*

   JW: If we were working on diesel trucks, we'd concentrate on decreasing NOx. But NOx is at low levels in two-stroke engines, and not a problem. Our objective was to measure what the emissions were, and determine the effects of fuel and lubrication oils on emissions—both reductions and increases.

9. *Is NOx higher in four-stroke snowmobiles?*

   JW: Yes.

10. *Isn't ozone the main problem with NOx?*

    HH: In Yellowstone, it's usually cold enough to prevent ozone generation.

11. *So in reality, NOx isn't really a major problem for snowmobiles?*

    JW: Right.

12. *But hydrocarbons are a problem?*

    JW: Yes.

13. *So snowmobile manufacturers don't especially need to worry about NOx?*

    JW: Right. Carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM) are the big three.

    HH: We've found ammonia in the snow, too. And sulfate ions proportional to snowmobile traffic. In laboratory tests, we confirmed that these two-stroke engines produce ammonia. However, we haven't been able to find ammonia in snowmelt water. We're not sure if it outgases, or if biological activity eats it up.

14. *Have you found any particulate matter or other pollutants in the water?*

    HH: Yes. George Ingersoll and NPS have looked at snow and water quality issues. Emissions, both particulate and hydrocarbon emissions tended to be concentrated in the snow in and along trails, and some things in the runoff water. MSU researchers found some things in runoff water. MSU did not find these pollutants in soil.

15. *Have you seen formaldehyde with ethanol blend*?

    HH: Yes, although formaldehyde levels are greater with regular gasoline than with ethanol blend. Acetaldehyde increases in ethanol blend, although Kado's studies indicated that it doesn't stay around long in the environment..

16. *What kinds of "things" were found in runoff?*

    HH: Can't remember. (A review of the Ingersoll's 1999 report page 20 show that the runoff water contained detectable and/or measurable levels of calcium, magnesium, chloride, sulfate, and toluene. Samples were also evaluated for benzene, MTBE, m- and p-xylene and o-xylene, but these compounds were below the confidence levels of detection. Ingersoll did not find pollutants at levels of concern to human health or the ecosystem. However, pollutants have been measured in runoff at levels toxic to aquatic microorganisms. These may have impact at localized sites such as ponds.

Two-Stroke Engines vs. Four-Stroke Engines
The next section of the workshop was a comparison of two-stroke versus four-stroke engine technology and emissions by Jeff White. He also discussed the difference in performance and fuel efficiency between these two types of engines.

Questions for Jeff White:

1. *Does the use of oxygenated fuels reduce emissions from a four-stroke engine?*

   JW: Probably. There's little emissions improvement in automobile engines, however, because of the way engine feedback systems work.

2. *Does direct injection (DI) affect the quantity of fuel used?*
   JW: Yes, the DI two-stroke is considerably more fuel-efficient than a carbureted two-stroke. (The Clean Snowmobile Challenge found that the "control" snowmobile had a fuel consumption of 9.7 miles per gallon (mpg), the University of Waterloo's two-stroke snowmobile had a fuel economy of 17.3 mpg using DI, and the State University of New York at Buffalo's four-stroke 500cc Polaris engine snowmobile had the winning fuel economy of 27.7 mpg.)

3. *Is direct fuel injection (DFI) more efficient than DI? Is this a completely different kind of injector from the one used on passenger cars?*

   JW: With a two-stroke it is an electronic injection, with four-stroke it is injected behind intake valve under low pressure. With two-stroke, direct fuel injection is a higher pressure, more expensive, electronically controlled.

4. *What are the chances of a four-stroke that meets air quality requirements in YNP and is also a good "off trail" machine?* Renters want to be able serve areas both inside and outside the YNP. There are concerns about the weight of four-stroke engines and their lower power and speeds.

   JW: Haven't seen the emissions data on the new four-strokes yet.

5. *[Commenting on the Arctic Cat four-stroke demo vehicles that many people drove] The RPMs were higher than I expected at "shift out." Why is this?*

   JW: The power and torque curves on four-strokes are very different from two-strokes. The transmission is very different.

Emissions Research in Yellowstone National Park
Howard Haines gave an overview of the research done on emissions, energy efficiency, and monitoring in and around the Yellowstone National Park (YNP). A section focused on measurements taken at the West Entrance to the YNP in Montana where carbon monoxide concentrations were found to be higher than elsewhere in YNP.

Questions for Howard Haines:

1. *Is air quality being monitored along trails inside the Park? Or just at the entrance?*

   HH: Only at the entrance. Most of the Park is in Wyoming, and Montana DEQ is not monitoring these areas.

2. *What are the highest air pollution "spikes" that have been observed at the West Entrance?*

   HH: The highest readings in 1999 were 18.2 ppm CO 1 hr average that occurred on President's Day weekend during stagnant air conditions. In 1998 the highest reading occurred in October. (NOTE, the statement made during the workshop is incorrect. The October readings did not pass the standards for data collection (Quality Assurance analyses) as explained below. The highest carbon monoxide readings were in December 1998, not October 1998).

3. *[Follow up] Why such a high reading in October?*

   HH: One possibility is wood smoke, from homes in West Yellowstone. Note: October data did not pass DEQ's quality assurance check. This procedure assures that the equipment is properly calibrated and functioning correctly during data collection. The installation at the West Entrance was installed in September 1998. As with other installations at start-up, something was discovered during the QA check that did not pass the tests, so the data were not valid during most of October. The highest CO reading at the West Entrance was 11.1 PPM CO 1-hour average at 4 PM, December 22, 1998 with weather data (wind and temperature) indicating stagnant conditions. Attached is a summary report of the highest 1-hour and 8-hour CO averages for calendar year 1998, 1999, and 2000 for the January 1 through September 30 period.

4. *Are readings also being taken in the summer?*

   HH: Yes. They are generally much lower than winter readings. The highest reading during the summer of 1999 was 3.5 PPM CO 1 hr average.

5. *Is the West Entrance a good place to monitor carbon monoxide [CO]? Why monitor at the worst place, instead of choosing some more typical location?*

   HH: Yes, the West Entrance is a good monitoring point. It makes sense to find and monitor for CO at the worst location. If the CO problem can be solved at the location most likely to have CO problems (the worst location), then we can assume that other areas do not have the CO problem.

6. *Is carbon monoxide from fireplaces included in the winter measurements?*

   HH: There's no way of distinguishing the sources of CO. The source of particulate matter [PM] can be determined in analysis.

7. *So you're saying that these high CO readings, that have been so heavily hyped in the press, could be coming more from fireplaces than from snowmobiles?*

   HH: No. The spikes consistently match spikes in snowmobile traffic. Older snowcoaches are a problem too.

8. *How fast does CO go away?*

   HH: Unlike PM and hydrocarbons, CO does not react quickly. High readings tend to remain high overnight, and when inversions occur the CO hangs in a big cloud.

9. *[Comment] But maybe wood stoves are causing these consistently high nighttime measurements.*

10. *Why use the worst emissions measurements to determine the effect of snowmobiling on the environment?*

    HH: The question is 'why use only high readings of pollution to measure the effect of snowmobiles on the environment, instead of the average readings? Basically, high levels of pollution are scientifically proven to cause health problems and there are laws to help protect the public health. This effect is worse on children and elderly—populations that have little chance to move out of the pollution or pay for its medical costs. The Clean Air Act of 1970, was passed to protect the general population and certain areas like Yellowstone National Park from the affects of pollution. The law set standards and measuring procedures based on the science. So when high readings of pollution are recorded using these methods, then there is a good potential for a public health problem. The law provides for occasional high readings, and does not take action until the second high reading is verified. High pollution readings from natural causes like forest fires can be explained by the state. needs further investigation—typically a minimum of 3-years of study. The measurements do not determine the impact on the environment, and are not the only data used for evaluation. There are several data points. For example, PM is measured in town too, and then measured at four sites in the area simultaneously, to get a more complete picture of how the particulate pollution is distributed throughout the West Yellowstone-Old Faithful area.

11. *Is CO measured in town?*

    HH: No.

12. *Is it fair or reasonable to use the entrance as a measurement point? I've heard that you can manipulate air quality measurements at the entrance by simply opening or closing a kiosk.*

    HH: The air quality monitoring site is located so that man-caused obstructions do not interfere with collection of ambient air measurements. This means that the largest impact on air quality measurements would be the weather, not opening or closing of lanes. Several management techniques can be used to reduce emissions. Use of ethanol blend fuel and express lanes help by reducing the amount of idling at the

entrance. We've had express lanes for three or four years but they were not consistently used until the 1999-2000 season.

13. *Who or what is affected? Has anyone done tissue samples?*

    HH: Last year the University of California/Davis studied National Park Service (NPS) employees, monitoring exposure to benzene, toluene, fine particulate matter, and CO and calculating long-term health risks. They found that mechanics and patrol rangers on snowmobiles had the highest exposure levels. The Occupational Safety and Health Administration (OSHA) levels (enforceable legal mandates) were approached only for mechanics. Benzene, toluene, and PM approached the National Institute of Occupational Safety and Health (NIOSH) standards over three weeks out of the year. NIOSH standards suggest that mechanics, kiosk operators, and rangers were all experiencing high exposure levels that could impact their long-term health.

14. *What are rangers and mechanics doing during their off-hours? Could this be adding to their exposure? (E.g. maybe some are working on vehicles in poorly ventilated garages.)*

    HH: The UC Davis study looked only at exposure levels on the job. Participants carried canisters that recorded exposures.

15. *Were these studies repeated this winter?*

    HH: No. They were done last February 1999. Note: OSHA completed an initial study in February 2000 on CO, benzene, formaldehyde and diesel emissions (total carbon and particulate matter).

16. *I've heard that emissions levels are much lower away from the entrance station. Aren't the kiosks the problem*?

    HH: Partly. There appears to be a problem with that location, since it's a low point with little wind, subject to inversions, and also the greatest concentration of slow moving or idling machines.

17. *Why attack emissions so hard? Aren't these just a problem at the entrance point?*

    HH: The mechanics and patrol rangers weren't just sitting at the gate.

18. *Aren't all of these criticisms based on a worst-case scenario, when the maximum number of snowmobiles enters the Park? How do these peak levels compare with average days, when 400-600 snowmobiles enter? Wouldn't emissions on these more normal days be less than half the peak measurements?*

    HH: Measurements are continuous, so these aren't just worst-case scenarios. You can't assume that air quality measurements drop by half when half the snowmobiles enter or individual machine emissions are reduced, since inversions may keep the emissions high. DEQ modeled a worst-case scenario to determine the impacts of different management alternatives in the Yellowstone Winter Use Plan EIS. The "worst case" projections in the EIS analyses have not yet been experienced at the

monitoring site. Also, during the Kado study in February 1999, high levels of CO were measured with just 297 snowmobiles entering when stagnant air conditions existed for a few days. Field studies discovered that increases in CO levels in the air do not proportionally correlate with the number of snowmobiles. A correlation was found with particulate matter (PM-10) measured in the morning periods and the number of snowmobiles—in other words, an increase in the number of current technology snowmobiles entering the park would have a direct increase in the amount of particulate matter measured. For those that are interested there is a table available reporting the high readings to EPA.

19. This data all seems to be from last year. Hasn't air quality this year been better?

HH: We are monitoring now, and hope to be able to compare President's Day weekends. We got very good data collection on President's Day weekend February 1999, and 2000.

20. In the UC Davis study, did workers wear their filters through the workday?

HH: Yes. They wore monitors with filters.

21. Did they wear them through the whole season?

HH: No. The study took place during a 10-day period. They used a new monitor filter each day for both high and low entrance data (low was 297 snowmobiles entering, high was 967 machines entering).

22. *What do we know about exposure to snowmobile riders*?

HH: The EPA regulations don't cover this. It might be comparable to the levels in patrol rangers, but we have no data. Lori Fussell has looked at CO exposure levels for people travelling behind other snowmobiles for modeling purposes only. That is, to be able to mathematically estimate the emission level of a compound for a given distance and speed behind a snowmobile. But CO emissions were found to not be proportional to the number of snowmobiles operating in the area, and CO doesn't proportionally track emissions of PM and hydrocarbons.

23. Who in the National Park Service said that tread-mounted vans got 18 miles per gallon? That's unbelievable.

HH: This was an assumption used in their report. I agree that it's not a believable number. Note: This statement at the workshop was wrong. The table information was misread. NPS used 1-3 mpg for snowcoaches.

24. So this emissions monitoring is sponsored by Montana DEQ, EPA, and other groups? Who receives the raw data?

HH: There have been seven different studies. DEQ performs a quality assurance check on the raw data before it is released to EPA and the public. This check is to

determine that the equipment is working properly and the equipment is properly calibrated. Other research like that of U.S.G.S and the University of California at Davis had similar checks to validate data. EPA hasn't funded air quality monitoring, but is funding outreach and educational programs, including this workshop. Other funding partners would include Montana DEQ, snowmobile manufacturers, and the West Yellowstone Chamber of Commerce.

25. *[Comment] It seems to me that these data could be used to prove anything.*

    HH: The goal was to identify emissions, solutions, and alternatives. There are some things we have proven with the data. For example, NOx and ground-level ozone are not problems from snowmobiles in winter. Ethanol blend fuel reduces emissions. The right low-emissions lubricant can reduce emissions, and/or the impact of particulate emissions. The impacts of emissions are localized near snowmobile use. The unburned fuel and lubricant in the exhaust can be a health problem.

26. *What is the problem? <u>Is</u> there really a problem?*

    HH: The problem is exposure to high levels of emissions of CO, PM, and other airborne toxics, such as benzene and toluene. CO can intoxicate or kill you, like in a closed garage with the car running. Benzene is a known carcinogen and acts in the blood-stream on a long-term basis. This is a real problem for young children. The fine particulate matter is inhaled, and is so fine that very few filters can be of much help. This fine particulate matter can cause asthma or heart problem flare ups. These emissions affect children and elderly more so than working adults tested in the personal exposure studies.

27. *For all snowmobiles? Or only for people who work at the West Entrance? I'm from Michigan, and no one stops me from driving in with my own machine. If the problem is at the gate, surely that's easy to fix.*

    HH: For now, the problems appear to be for all snowmobiles that operate where congestion may occur—not just Yellowstone. The problem has many aspects: For example, exposure levels are highest for mechanics, rangers, and sled operators at congested areas like parking lots, and poorly timed machines will contribute more to the problem. Skiers and snowshoers also would be exposed to high pollution levels.

28. *How does the overall air quality in YNP look?*

    HH: Yellowstone National Park is a Class I airshed by definition, and as such, it should be "clean." From a Montana regulator's perspective, you don't look at the overall average. Policy planning looks at the probable air quality of an area. But transportation fuels impact air quality, and oxygenated fuels are helping to reduce

the problem. One million gallons of oxygenated fuel saves 61 tons of CO, and Park visitors purchase something like 5 million gallons of fuel each winter in West Yellowstone alone.

29. *What about emissions from snowcoaches?*

    HH: Last fall NPS came out with a report on air quality concerns. A revised report is coming out which corrects many of the errors in the first draft. (Note: The revised report was released the same day as the West Yellowstone workshop. The revised (February 2000) NPS report accurately describes the NPS air quality concerns and research up to December 1999. There are laws and executive orders that NPS must adhere to that cover more areas than just air and water quality.)

30. *Isn't the problem with mechanics primarily an employer's issue, one of providing proper ventilation?*

    HH: Partly, yes. But many mechanics are on the road too. Also, the patrol rangers and kiosk workers had documented problems. It's a combination of factors.

31. *What were the duties of these mechanics? What kinds of machines were they working on?*

    HH: Snowmobiles and groomers, primarily.

A Snowmobile Rental Business Perspective

Glenn Loomis gave a presentation discussing his use of ethanol blend fuel and low emission synthetic lubricants. He has been using a variety of biodegradable and synthetic lubricants since 1996. Starting in 1997 they started using Conoco Biodegradable synthetic lubrication oil. During the last two winter seasons of 1998-1999 and 1999-2000, they have been using Arctic Cat Premium Gold. Although it costs more to use these oils, a byproduct of using this fuel and these lubes was that they use up to 50 to 60 percent less maintenance on the fleet.

Questions for Glenn Loomis:

1. *What is the name of your business?*

GL: Traveler's Snowmobile Rentals

2. *[Comment] I'd like to commend Glenn and the other rental companies in West Yellowstone for their voluntary use of oxygenated fuels and biodegradable lubricants. Why aren't similar measures being taken in Jackson and other towns? Note: This season, some operators out of Jackson and Pahaska Teepee used ethanol blend because it is available.*

3. *Glenn said that emissions are greatly reduced at the West Entrance, and speculated that oxygenated fuels may be one reason. Has this success story been published?*

   GL: Positive stories don't make headlines.

HH: Doesn't know if this has been in the news. (Note: Cleaner air in West Yellowstone was the headline in the Bozeman Daily Chronicle the day after this workshop).

4. *In using biodegradable lubricants, do you need to mix the oil and fuel manually?*

   HH: No, you don't need to mix it manually, it gets mixed before it goes into the carburetor.

5. *[Comment from another rental business owner] The ethanol blend puts an end to carburetor icing, and also makes machines a lot easier to start.*

6. *Will service stations in the YNP start selling ethanol blend fuel?*

   HH: It hasn't been possible this winter, since fuel orders were already in. The stations are hoping to have one pump at each station selling ethanol blend next winter. Since July 1998 NPS has been using ethanol blend fuel year-round in all gasoline-powered equipment. NPS has been using biodegradable lubricants since December 1996. Note: Starting in October 2000, ethanol blend is available at public service stations in Yellowstone and Grand Teton National Parks (including Flagg Ranch).

7. Why don't we just set an emissions standards for vehicles? This would seem like the simplest approach. (In many states, this is already being done for automobiles.)

   GL: The question becomes "How high do you set the bar?" Debate about emissions has driven people away from standards.

Clean Snowmobile Challenge

At this point Lori Fussell provided information about the Clean Snowmobile Challenge (CSC) 2000 that was to occur later in March 2000. The CSC 2000 requires college student teams to design a snowmobile with reduced emissions and noise characteristics that also equals or improves upon the performance of current snowmobiles. Events scheduled to take place during the CSC 2000 include: emission testing, acceleration event, hill climb event, cold start testing, noise measurement, fuel economy/range event, and oral/written design. Schools participating include two from Canada and five from the United States.

In response to increasing concern about snowmobile noise and air pollution in environmentally sensitive areas, various partners got together to conduct the Clean Snowmobile Challenge 2000. The goal of the CSC2000 was to develop a snowmobile with improved emission and noise characteristics that did not sacrifice performance. Modifications were expected to be cost effective and practical.

The CSC2000 was held in and around Jackson Hole, Wyoming from March 20 – 31, 2000. Participating universities competed against each other in the categories of emissions, fuel economy/range, noise, acceleration, handling, cold-start, hill climb, engineering design

paper, oral presentation, and static display. Points were awarded to teams based on their performance in each of the events.

The University at Buffalo won the CSC2000 with a snowmobile featuring a four-stroke engine and catalytic aftertreatment. This first-place entry was successful at reducing noise and emissions while simultaneously improving fuel economy. However, it did experience some loss of performance capability.

The University of Waterloo took second place in the CSC2000 with a snowmobile featuring an advanced two-stroke engine and catalytic after-treatment. The Waterloo entry significantly reduced emissions while simultaneously improving performance and fuel economy. However, noise from this entry did not meet competition standards.

Through the CSC2000, a first step has been taken to solve the noise and emission challenges presented by snowmobiles. Although many CSC2000 participants would have benefited from additional development time, the results from the first year of the Clean Snowmobile Challenge Collegiate Design Series clearly demonstrate that the noise and emission problems associated with traditional snowmobiles can be solved through advances in engine, noise control, and emission control technology.

Using a four-stroke engine and catalytic aftertreatment, the University at Buffalo (UB) was successful at reducing CO emissions by 46% and UHC emissions by more than 99.5%. The UB snowmobile's maximum exterior sound level was reduced to conversational levels (66 dBA), 50 feet from the road. Additionally, the fuel economy of the UB snowmobile was increased to 27.6 miles per gallon. The only weakness in the UB snowmobile was its acceleration performance, which was decreased by approximately 25%.

The University of Waterloo (UW) entry proved that advanced two-stroke engines show promise as well. The UW snowmobile featured an advanced two-stroke engine with catalytic aftertreatment. The UW snowmobile's CO emissions were reduced by 47% and UHC emissions were reduced by 95%. The fuel economy of the UW snowmobile was increased by 41%, to 17.2 miles per gallon. Additionally, its acceleration performance was 0.6 seconds faster than the control snowmobile. This design, however, was unsuccessful at meeting the stringent CSC2000 noise requirements. Therefore, noise reduction from advanced two-stroke engines remains an issue requiring further research.

Questions for Lori Fussell:

1. *Why are you allowing the use of composite materials and chassis modifications?* This seems to give an advantage to schools with more money.

   LF: That's a fair comment.

   Twenty five percent of points are for design evaluation and factored into that is an evaluation of the cost, to judge if what they are doing is practical.

2. *The rules would seem to give an unfair advantage to four-stroke designs.*

   LF: Actually this isn't true. We allowed 800cc for four-stroke, 500cc for two-stroke, which seems to give a slight advantage to the two-stroke designs. But in any case, there were no 4-stroke entries this year in the six of seven papers we have received so far this year.

3. *Do you plan to modify the competition rules for 2001?*

   LF: Yes. Schools will generally have more freedom.

4. *Will the same schools compete in 2001?*

   LF: We sent out "intent to compete" forms to all SAE schools worldwide. We've received 15 intents, including schools in Lithuania, Canada, and the United States.

5. *Who are the seven schools competing this year?*

   LF: Colorado State, the Colorado School of Mines, Michigan Tech, École de Technologie Superiore (Quebec), State University of New York at Buffalo, Minnesota State - Mankato, and the University of Ontario.

6. *Why do you allow superchargers but not turbochargers?*

   LF: In theory, all two-stroke engines are superchargers. So we had no choice but to allow these.

7. D*o you allow nitrous oxide?*

   LF: No. We don't allow fuel additives.

Open Panel Discussion

Questions for panelists, including Howard Haines, Jeff White, Glenn Loomis, and Lori Fussell:

1. I*s EPA going to consider new technologies for the Park?*

   HH: The decision for the Park is being made by the National Park Service (NPS), not EPA. At this point, NPS has announced that they are leaning towards a "no snowmobiles and snowcoach-only" policy for Yellowstone and Grand Teton beginning in the winter of 2002-3.

2. *There was no date on the letter from NPS. When was it received?*

   HH: It was written before December 15. The Greater Yellowstone Coalition (GYC) had requested and received a copy. Three weeks later GYC released this letter to the press.

3. *[Comment] Maybe it's time to "go the political route."*

4. *[Comment] This announcement may turn out to be a blessing in disguise. Now we know what we're dealing with. We also know that we have the technologies to solve these problems.*

5. *Aren't four-stroke snowmobiles cleaner than existing snowcoaches?*

   HH: The University of Denver has looked at emissions of just two snowcoaches.

6. *Is the NPS announcement related to the decision to close off roadless areas in National Forests?*

   HH: That's not on the agenda.

   GL: It's driven by the same administration. The Clinton administration wants to "save" Yellowstone from snowmobiles again this election year, just like they "saved" the Park from the gold mine in the last election year.

7. *[Comment] Snowmobiles have been picked on unfairly in the Park since the mid-1970s.*

8. *[Comment] There's a double standard when it comes to noise. There were lots of open-piped Harleys in the Park this summer. As an experiment, I drove a car without a muffler through the Park twice this summer, to see if I'd get questioned. No one stopped me or questioned me.*
9. *Has anyone thought about limiting the number of people allowed in through the West Entrance?*

   HH: NPS has considered lots of alternatives.

10. *[Comment] We're talking about an agenda here. The recent moratorium on road construction and logging in roadless areas is part of it. They are putting snowmobiles under a microscope for political purposes. Airplanes use vastly more fuel and are not pollution-controlled.*

    GL: There's room for improvement on snowmobile noise and emissions. Some criticisms are legitimate, and it's not necessary to have the noise and fumes. I'm opposed to being stampeded into doing the right thing for the wrong reasons.

11. *Doesn't a lot of the exhaust and noise problems come from aftermarket snowmobiles?*

    GL: True. Responsible aftermarket companies have done a lot to make improvements. I applaud efforts to make machines quieter. We shouldn't have loud machines.

12. *[Comment] Noise is relative. Some people today have an attitude that things should be silent.*

13. *[Comment] There is an agenda at work here. Every four years we can turn the country around, and if you don't vote you have no right to own a snowmobile. Vote for "our" candidates, including Conrad Burns and George W. Bush.*

14. *[Comment] When you talk to your neighbors and speak out in public forums, don't say the word "snowmobile." Talk about things like land access, fair and equitable fuel use, and freedom.*

15. *[Comment] What's acceptable to some individuals will always be unacceptable to others. Skiers complain about snowboarders too. There ought to be ways for snowmobiles, snowcoaches, and others to coexist. It's not right to slam the door on 70,000 people.*

16. *Now that we're seeing $2 gasoline prices, some of us are wondering why we haven't been worrying about increased efficiency and economy all along.*

    JW: Up until now it hasn't been economically affordable for an individual company to invest in developing cleaner machines. EPA will help industry by imposing standards. You're going to see a better-engineered product, just as we've seen in the auto industry. EPA's decision may also take some of the heat off West Yellowstone and other local communities.

17. *[Comment] I disagree with the idea that EPA regulation is good for industry. With each new regulation you lose freedom.*

18. *[To Glenn Loomis] What is the lifespan of your rental fleet?*

    GL: We run new machines every year. We won't be able to invest much money if snowmobiles will be banned from the Park in 3 years, however.

19. *[To Glenn Loomis] Would you use a (four-stroke) Trail Roamer for two years instead of one, because of its higher cost?*

    GL: Probably not. People expect to rent new (i.e. current model year) equipment, and the machine would probably be too badly beaten up after two years anyway.

20. *[Comment] Snowmobiles will never be as fuel-efficient as today's cars. Driving a snowmobile is like playing volleyball on the beach. The vehicle has to work fairly hard, even on a packed trail.*

West Yellowstone Workshop Conclusion

Over 55 people attended the Clean Snowmobile Technology workshop. There was representation from many diverse points of view. This included land managers, representatives of government agencies, snowmobile manufacturers, snowmobile rental businesses, and interested community members. Not surprisingly there was little acknowledged representation from the environmental conservation perspective. Despite the attempt by the audience to steer the event towards a debate of land use regulation, there was an abundance of questions regarding the new technologies available as well as the benefits and potential extra costs associated with these technologies.

Packets were given to all attendees including a copy of an article by Howard Haines entitled "The Snowmobile Dilemma, or, Who Spilled What in the Refrigerator vs. Who's Going to Clean It Up?"; a copy of the brochure "Make Your Snow Machine More Environmentally Friendly" published by the Montana Department of Environmental Quality; an article published in December 1999 SnowTech magazine entitled "The Facts about Snowmobiles and Emissions"; and a "Bibliography of Snowmobile –Related Emissions and Air Quality Studies".

Following the West Yellowstone Workshop, DEQ and its contractor, NCAT, presented workshop and discussion sessions at Durango, Colorado (March 20-21, 2000, over 80 in attendance), Gaylord, Michigan, (August 8, 2000, over 55 in attendance), Grand Rapids, Michigan (August 9), Lansing, Michigan, (August 14 and 15, 2000, over 84 attending), Milwaukee, Wisconsin (September 11, 2000, over 72 in attendance, Ashland, Wisconsin (September 20-21, 2000, over 22 senior National Park Service and National Forest staff in attendance), and Driggs, Idaho (November 13 and 14, 2000, with over 30 in attendance). Reports on these events were made in other monthly reports. Most of the attendees were officers of clubs or represented other organizations. Several are distributing the information within their organization. This is confirmed indirectly by the number of requestors who did not attend but wanted additional information. For example, the Michigan Snowmobile Association (addressed in Gaylord and Grand Rapids, Michigan) copied and distributed the information to its 155 member clubs (representing over 1 million registered members) as part of their education and safe drivers campaign. Comments from these workshops indicated that an event like the Minnesota Winter Sports Show might reach a large number of operators in a short time.

SECTION II

MINNEAPOLIS WINTER SPORTS SHOW

The final free workshops for this project took place on November 11th and 12th, 2000 in Minneapolis, MN. Along with the two scheduled workshops, NCAT created a portable static display to promote clean snowmobile technologies. This display will be available for use in the future at other events as well. Due to the flexible design characteristics of the display, it will be able to be modified for specific events and audiences.

Portable Static Display

For the entire three days of the show, a 10' x 10' booth was set up to inform people on the current status of Clean Snowmobile Technology. There are 48 panels attached to this display this includes 12 panels addressing four topic areas; Emissions Research, Alternative Fuels and Lubricants, Clean Snowmobile Challenge 2000, and New Engine Technologies. In addition to this display, there was a table with a variety of brochures and technical papers available for free distribution. Packets were given to all attendees that included a copy of an article by Howard Haines entitled "The Snowmobile Dilemma, or, Who Spilled What in the Refrigerator vs. Who's Going to Clean It Up?"; a copy of the brochure "Make your Snow Machine more Environmentally Friendly" published by the Montana Department of Environmental Quality; an article "Development and Validation of a Snowmobile Engine Emission Test Procedure" published by the Southwest Research Institute, and a "Bibliography of Snowmobile –Related Emissions and Air Quality Studies". There was also a person to staff the booth during the entire event, and to answer questions and offer brochures.

Workshop A

The first workshop of the Minnesota event was held on the afternoon of November 11. Howard Haines began the presentation by explaining the research that had been done on emissions and noise. Jeff White gave a presentation on the specific qualities of two-stroke engines, and the work that the Southwest Research Institute had done on the use of ethanol fuels and biodegradable synthetic lubricants that were effective at reducing emissions. Howard Haines concluded with information on the Clean Snowmobile Challenge.

Workshop B

The second workshop of the Minnesota event was held on the morning of November 12. The program was similar to the previous days workshop with an additional presentation by Jeff White on the Characterization of Snowmobile Particulate emissions. The was in response to the interest on this specific topic by one audience member representing the American Lung Association.

Questions for Howard Haines:

1. *Were the improvements in emissions made at the entrance kiosk in Yellowstone the result of getting the snowmobiles moving through the gate, or were there other factors?*

HH: Getting them moving through the gate was a significant factor in the reduction of emissions, but we are not certain that was the main reason emissions were reduced.

2. *Were the OSHA studies done before or after the clean-up strategies were put in place?*

   HH: The studies were done during the clean up, so these data reflect the result of using ethanol fuels and pre-paid passes to keep the snowmobile operators moving through the gate.

3. *Is it true that there were no pollutants found in the puddles or streams in the test area?*

   HH: Nitrates and ammonia were found in the snow pack, but the levels in water samples were low to non-detectable and not enough to impact health. The data from the water samples came from studies done in 1971 that were looking for lead, and should not be considered current information.

4. *Are snowmobile helmets sufficient to reduce the noise to an acceptable level?*

   HH: 60 decibels is the Federal Quiet Area Standard. A standard snowmobile helmet does provide sufficient protection, but snowshoers and cross-country skiers will not be protected from excessive sound levels.

5. *What is the status of the EPA emissions standard for snowmobiles?*

   HH: On November 17th of 2000 there will be an announcement on the opportunity for feedback on the testing procedure that will be decided on September 2001.

Questions for Jeff White:

1. *Is there a difference between the emissions from a diesel two-stroke and diesel four-stroke?*

   JW: The diesel two stroke has higher particulate matter emissions. The two-stroke diesel engine will eventually be phased out of usage.

2. *What is the two-stroke diesel being used for?*

   JW: It is used for buses where the need for a lightweight engine is important.

3. What snowmobile manufacturer seems to be creating the cleanest machines?

   JW: Artic Cat seems to consistently have the lowest emissions for comparable sled types.

Observations at the Minneapolis Event

The estimated attendance at the Minneapolis Winter Sports show was between 10,000 and 12,000. If there was one person in one hundred who stopped to look at the static display, a conservative estimate, that would mean that there was between 100-120 that took the time to learn of these technologies. The workshop that took place on Saturday afternoon from 2:30-4:00 was attended by 15-20 people, some of whom had attended the workshop in West Yellowstone and were interested in current information. The workshop on Sunday from 10:30 a.m. to noon was attended by 5-10 people. Several brochures on Clean Snowmobile Technology available for distribution, and there was a sign-up sheet for persons wishing to receive more information. We have included the names from the sign-up sheet with this report.

There was a select, but consistent interest in the display. A common question was "Are you one of those environmental groups that wants to keep snowmobiles out of National Parks?" To which I would answer "No, we are attempting to provide the snowmobile community with the latest information on technologies available to reduce emissions and noise while not adversely effecting performance." There was much less of a confrontational attitude at the events in Minneapolis than the one in West Yellowstone. It was very apparent that the media had done a good job of creating the impression that Yellowstone National Park was closed for the winter of 2000-2001, despite the inaccuracy of that information, based on several questions
NCAT received from individuals. Several people in their early twenties were very interested in the display and the Clean Snowmobile Challenge in particular. One of these people was on the Michigan State team that was in last years CSC events, and was looking forward to CSC 2001.

Four hundred postcards were sent by mail to people on the MT DEQ mailing listing one month before this event. In addition there was a ¼ page advertisement placed in Snow-Tech Magazine in the issue that came out a week before the event. The Minneapolis Star was contacted about the event, however to my knowledge, there was no reporter present at either of the workshops. There were large signs posted on both Saturday and Sunday at the entrance to the show announcing the workshops. In addition to this there were several announcements made prior to each workshop over the loudspeaker. Some attendees indicated they had a hard time locating the area were the seminars were taking place.

SECTION III

OVERALL CONCLUSIONS AND RECOMMENDATIONS

Two workshop models were explored during the course of this educational outreach project:

Targeted Audience Workshop

The first model was that of the Clean Snowmobile Workshop in West Yellowstone. This approach was targeted at a specific community that was being challenged by the proposed closure of Yellowstone National Park (YNP) to snowmobiles. Having a panel discussion that included at least one speaker from the community was an essential aspect of this format. Including someone who can discuss new technologies in layman's terms was a useful complement to the more scientific presentation approach as well.

General Audience Workshop + Static Display

The second model was that of the workshops held in Minneapolis at the Winter Sports Show. The Minneapolis workshops were not attended by as many people as the workshop in West Yellowstone, but many viewed the static display, and including these people there were easily over 100 people that were reached by the display and workshops in Minneapolis. The two types of information outreach methods are both viable approaches for this type of effort. The Targeted Audience Workshop is better for a specific community or group that may be affected by changing legislation regarding snowmobile emissions. The static display set up at a large event like the Minneapolis Winter Sports Show is best suited for a more general audience. The impact is more diffuse with a less acute response.

Overcoming Challenges in Educational Outreach

The process of disseminating information presents three major challenges. First, "you can bring a horse to water, but you can't make it drink" as the saying goes. This example holds true for convincing people about the demonstrability of clean snowmobile technology. It's good to inform snowmobile operators of the risks they are taking by breathing in toxins and being exposed to high noise levels, but snow machines are not likely to change unless performance is enhanced in the process. Snowmobile enthusiasts would rather hear that a properly adjusted carburetor will increase fuel efficiency and reduce cost of operation, that they can increase horsepower by using ethanol blend fuels, and that using synthetic, biodegradable lubricants in conjunction with ethanol fuels will reduce maintenance costs.

Second, the snowmobile industry is filled with marketing hype. In the context of neon colored machines, extreme performance videos and the glory of more horsepower, an information campaign must be bold to be successful. The static display is a step in that direction. Through its bright colors and flexible design, it will be useful at many different venues. Taking this to the next level by producing a "glossy" brochure, or a video or radio ad campaign in markets saturated with snowmobile enthusiasts could be very effective. A comprehensive and bold Internet site on clean snowmobile technology could have a profound effect on the size of the audience that this information would reach. The snowmobile enthusiast community is well represented on the Internet, and there is ample information on the politics of snowmobile access to public lands, yet there is a noticeable lack of information available addressing clean snowmobile technologies.

Third, there needs to be an increase in the number of snowmobile enthusiasts who are also strong advocates of new, cleaner technologies. The Clean Snowmobile Challenge is a perfect example of how much excitement can be generated around the need for cleaner, quieter machines. Progress will be made through events like the Clean Snowmobile Challenge and the coordination of folks like Glen Loomis, Bill Howell, Bill Schaap and Clyde Seeley, providing rental machines that use these technologies. Yellowstone Tour and Travel also will contribute by having a fleet of the Artic Cat four-stroke machines available for rental. These proponents have the respect of their peers and the greatest chance of success in convincing other snowmobile operators of the environmental and performance benefits to using these clean snowmobile technologies.

SECTION IV

POWERPOINT PRESENTATIONS AND PROMOTIONAL MATERIALS

This section includes photo-documentation of the portable static display, and print outs of Powerpoint presentations that Howard Haines and Jeff White gave at the workshops in West Yellowstone and Minneapolis. The are at a size of two slides per page. Files included are: Howard Haines' WashOct00.ppt. and Jeff White's Cleansnopt.ppt. Copies of the advertising and promotional materials used to encourage people to attend these two events are included as well.

SECTION V

CONTACT LIST OF ATTENDEES
This is a list of those who attended the workshop in West Yellowstone, and of those who requested more information from NCAT at the event in MN.

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